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Characteristics and distribution of breeding dens of the Red fox *(Vulpes vulpes)* in a mountainous habitat

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Abstract

Described the red fox breeding dens of a 30 km² area and compared them to the non-breeding dens. Dens were searched and controlled since 1986. In 1990 every den was characterized to examine their distribution and characteristics. The total number of dens was 62 (0.33/km²). 19.4 % of them were used for cubbing (1.88/km²). No significant difference in the characteristics of breeding and non-breeding dens was found except for the number of entrances, which was higher in the breeding dens. Man-made structures could be used as breeding dens as well as dens dug by badgers. The breeding dens were not further distant from roads and houses than the other dens. The breeding dens were not evenly spaced in the area and the same ones were generally used over several years. Results showed that the use and distribution of breeding dens was limited by the number of suitable sites. The number of breeding dens could be used to estimate the number of foxes in an area but this requires information on the social organization of the special fox population.

Introduction

Dens are used by the red fox *Vulpes vulpes* for two different activities: 1. as resting sites during the non-active period (non-breeding dens), 2. as sites for birth and rearing of cubs (breeding dens). Some dens are used for both activities. Several papers have described the characteristics of fox dens in different habitats (e.g. Fuchs 1973; Eiberle 1975; Weber 1983; Roman 1984; Iokem 1985; Paquot and Libois 1986), but there are only few data on breeding dens (Hewson 1986; Nakazono and Ono 1987; Brochier 1989). The question of breeding dens is important because it could provide useful information about a fox population, i.e., number of foxes, recruitment, and level of urbanization. In this paper we compare some characteristics of the breeding dens with the non-breeding dens, and show their distribution and use, using data obtained in a mountainous area in Switzerland.

Material and methods

Since 1989 and after a preliminary study of three years (Paratte 1989) we monitored the fox population of a 30 km² area in the Swiss Jura Mountains. The study area is described in Weber et al. (1991). The relief is karstic and the soils are shallow and unsuitable for burrowing, except in some small areas with peat. Roads and farms are numerous and evenly spaced.

Dens were found by walking systematically throughout the study area, using fox tracks in the snow during winter. Starting in March, every den was controlled every week in order to assess the presence of cubs. The occupation of a den by a fox family was confirmed by direct observation. In summer 1990, we checked every known den or den site in order to study their distribution and their characteristics. Each one was characterized using:

1. The type of habitat. Four categories were distinguished:
   forest (20.1 % of the study area), wooded pasture (25.2 %), pasture (31.9 %), and fertilized meadow (22.8 %). For "forest" two subcategories were made: "forest" and "forest's edge".
2. The type of substratum. The different possibilities were:
   a) den dug in the earth among spruce root system ("spruce root system") by foxes or badgers;

b) den dug in bare earth ("earth"); c) den situated in rocks ("rocks"); d) den situated in dumping-grounds, man-made accumulations of stones, wood, fire proof garbadges, ... ("dumping-ground"); e) combinations between these four categories: i.e., den with some entrances in the earth among spruce root system and some in bare earth ("spruce root system/earth").

3. The number of entrances: N.
4. The distance to the nearest road (main roads only) D_R.
5. The distance to the nearest house: D_H.
6. The distance to the nearest breeding den (for breeding dens only).

To test the distribution of the breeding dens, we compared the observed nearest distances between breeding dens with the nearest distances obtained by a simulation programme which set 12 points randomly (with the same probability for each surface unit) on the surface corresponding to the study area. Simulation was repeated 1500 times.

Results

Number and density

In spring 1990, the total number of dens regularly used by foxes in the study area was 62. Twelve of them (19.4 %) were used by 11 fox families as breeding dens: one family having moved, one week after the first emergence of cubs, to another den. Counting only one den for this family, the density of dens was therefore 1.88/km^2 and for breeding dens 0.33/km^2 (Fig. 1).

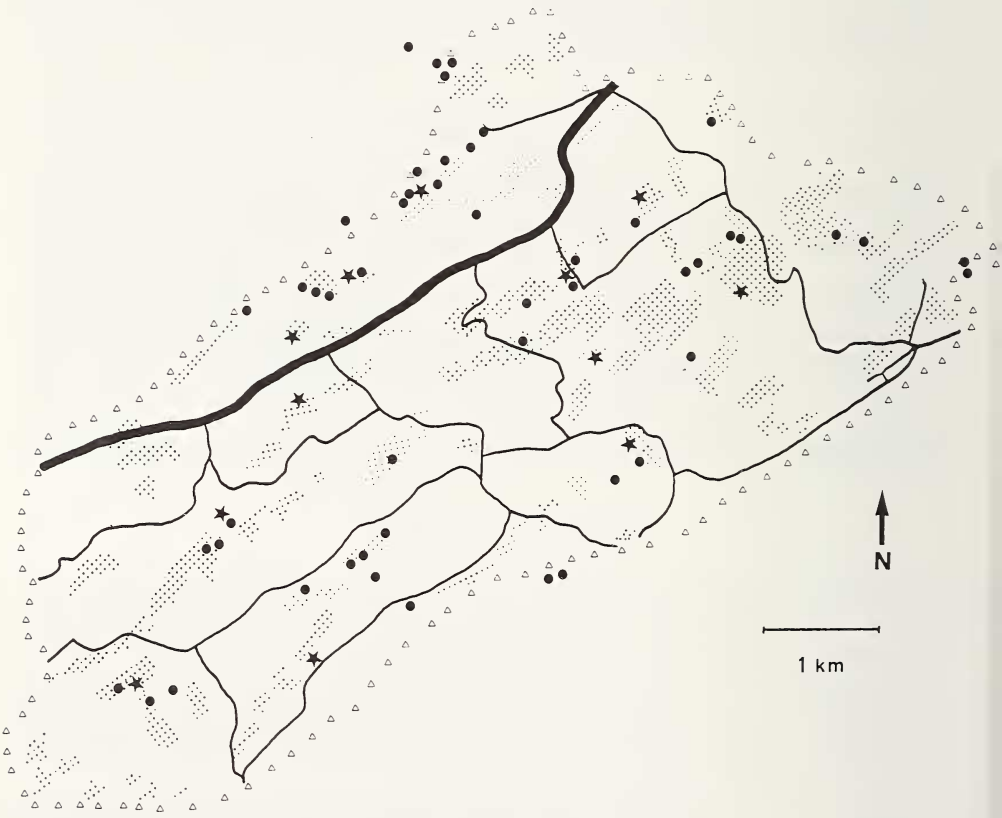

Fig. 1. Location of the dens in the study area in 1990. ▬▬: major road; ——: secondary road; △△△: limits of the study area; ★: breeding dens; ●: non-breeding dens; spotted: wooded areas

Characteristics

Six of the 12 breeding dens were situated in forests, all within 10 to 80 m of the edge, 3 immediately on the edge of forest, and 3 in wooded pastures. This situation did not differ from the location of the non-breeding dens (Fisher exact probability test, $p > 0.05$), (Table 1). Comparison of observed number of dens and expected number of dens in the different habitats showed a clear preference for covered areas: forests and wooded pastures (Table 2).

Table 1. **Comparison of the location of breeding and non-breeding dens**

	Breeding dens (N = 12)	Non-breeding dens (N = 50)	Fisher test
Forest	6 (50 %)	17 (34 %)	n.s.
Wooded pastures	3 (25 %)	25 (50 %)	n.s.
Pastures	0 (0 %)	3 (6 %)	n.s.
Forest edge	3 (25 %)	5 (10 %)	n.s.

Table 2. **Comparison of observed den locations with expected den locations**

Habitat and proportion (%) of study area	Breeding dens (N = 12)			Non-breeding dens (N = 50)		
	obs.	exp.	Binomial test	obs.	exp.	Binomial test
Forests (20.1 %)	9	2	$p < 0.05$	22	10	$p < 0.05$
Wooded pastures (25.2 %)	3	3	n.s.	25	13	$p < 0.05$
Pastures (31.9 %)	0	4	$p < 0.05$	3	16	$p < 0.05$
Fertilized Meadows (22.8 %)	0	3	n.s.	0	11	$p < 0.05$

obs. = observed; exp. = expected.

Most of the breeding dens (57.1 %) were situated in "spruce root system/earth" substratum; the proportion of the non-breeding dens in this category was lower (Fisher test, $p < 0.05$). Other substrata were "rocks/earth", "dumping-ground", or "spruce root system" (Table 3). Two breeding dens were a complex of two dens situated at a distance of 30 m and 80 m, respectively, and used simultaneously by the family (this explains the N = 14 in Table 3).

Table 3. **Comparison of the substratum of breeding and non-breeding dens**

	Breeding dens (N = 14)	Non-breeding dens (N = 50)	Fisher test
"Spruce roots system"	1 (7.1 %)	19 (38 %)	$p < 0.05$
"Rocks"	1 (7.1 %)	16 (32 %)	n.s.
"Spruce root system/earth"	8 (57.2 %)	9 (18 %)	$p < 0.05$
"Rocks/earth"	1 (7.1 %)	2 (4 %)	n.s.
"Dumping-ground"	3 (21.5 %)	2 (4 %)	n.s.
"Rocks/dumping-ground"	0 (0 %)	1 (2 %)	n.s.
"Spruce root system/rocks"	0 (0 %)	1 (2 %)	n.s.

All breeding dens had 4 or more entrances ($4 \leq N \leq 48$), whereas 72 % of non-breeding dens had less than 4 entrances. The number of entrances was significantly greater than in non-breeding dens (Mann-Whitney U Test, $p < 0.05$). The number of entrances was related to the type of substratum: more entrances were found when digging is possible – in "spruce root system/earth", "rocks/earth" – while dens in "spruce root system" and in "rocks" had less entrances (Kruskal-Wallis One-Way ANOVA, $p < 0.05$).

Distribution

As already illustrated in Figure 1, the breeding dens in our area were not evenly but rather randomly spaced. No significant difference was found by comparing the observed and the simulated distributions (Mann-Whitney U Test, $p > 0.05$).

The breeding dens were sometimes very close to houses ($125 \text{ m} \leq D_H \leq 900 \text{ m}$) or roads ($50 \text{ m} \leq D_R \leq 750 \text{ m}$). No significant differences were observed between the breeding dens and the non-breeding dens (Mann-Whitney U Test, $p > 0.05$).

Use of breeding dens

The first signs of occupation of a breeding den were found on April 17th. Removal of 8 fox families by their parents was observed between May 16 and July 12, the disturbance sources being cattle and man. Only one family moved to an already known den (situated at a distance of 1000 m), others were seen in the breeding den area but their new den sites were not found.

Nine of the 12 breeding dens which were occupied in 1990, were also used in 1986, '87, '88, '89, or '91. Two dens were used for cubbing 5 times during the six year period. Five dens were used 3 times, and the other two twice. The number of breeding dens over the six year observation period varied from 3 (1988) to 12 (1990) (Table 4).

Table 4. **Use of breeding dens**
Data from 1986–1988 according to Paratte (1989)

	1986 N = 6	1987 N = 9	1988 N = 3	1989 N = 11	1990 N = 12	1991 N = 10
"Combes"	+++	+++		+++	+++	+++
"Assesseur"				+++	+++	+++
"Biche"		+++			+++	+++
"Tuilerie"	+++	+++	+++	+++	+++	
"Brandt Nord"	+++	+++			+++	
"Brandt Sud"					+++	+++
"Puce"				+++	+++	+++
"Robert"	+++				+++	+++
"Bousset"					+++	+++

N = total number of fox breeding dens, +++ = den used.

Discussion

Except for the number of entrances, there was no significant difference in the characteristics of breeding and non-breeding dens. The preference for covered areas was already noticed by Weber (1983), Paquot and Libois (1986) and Iokem (1985). Only Nakazono and Ono (1987) observed that foxes used dens in open land rather than in densely vegetated areas. However, there is no contradiction between these two results which

correspond to two different strategies of the fox to assure the security of the den by using either a discrete site or a site with far visibility (Artois 1989). In fact, foxes are opportunists concerning their dens. They do not dig their own dens when other possibilities are available (Weber 1983). Thus, in our area, most of the dens that had been dug were made by badgers *Meles meles* and we observed either an alternate use by foxes and badgers or, in large dens, the possibility of cohabitation. The use of man-made structures (i.e. dumping-grounds) has been reported by Weber (1983), Paquot and Libois (1986) and Brochier (1989). However, a minimum distance to human habitations (50 m) occurred in our area; no vixen chose a site for her cubs directly close to or in a house, as urban foxes have been observed to practise (Harris 1977). We noticed that, when a breeding den was close to sources of human disturbance, the site was very densely covered and the cubs emerged only at night. The high number of entrances of breeding dens seems to be a constant characteristic (Weber 1983; Nakazono and Ono 1987) and probably corresponds to the need for the cubs to escape quickly into shelter.

The difference between breeding dens and non-breeding dens in the type of substratum was due to the number of entrances. When a den in the "spruce root system" substratum (most usual non-breeding den substratum) was extended, surrounding earth could be used and the substratum became "spruce root system/earth" (most usual breeding den substratum). We emphasize that the "earth" substratum was never found: entrances were dug in bare earth, only when a den was made larger.

The observed density of breeding and non-breeding dens was lower than those observed by Fuchs (1973) in the Swiss Midland (3.5–10.8 dens/km^2). It certainly depends on fox density but also on the possibility for digging. The soils in the Jura Mountains are generally shallow. The number of breeding dens (0.33/km^2) could be qualified as "medium": it is lower than in suburban Brussels (1/km^2) (Brochier 1989) but medium compared to Great Britain (0.03–1.3/km^2) (Hewson 1986).

Hewson (1986) showed that breeding dens in different areas of Scotland were evenly spaced. Nakazono and Ono (1987) supposed the same situation in Japan. Our results are different. The difficulty for foxes to find or make an adequate den for breeding could explain the random distribution; we consider that the distribution of breeding dens was limited by the number of suitable sites.

The number of breeding dens is related to the number of breeding vixens (Nakazono and Ono 1987) and thus it is an indication of the number of foxes (Hewson 1986). However, the estimation of fox density is difficult because the number of foxes in an area also depends on the social organization of the population: foxes usually live in pairs or in groups according to area and prey availability (Artois 1989). With foxes living in groups, Brochier (1989) counted 3 individuals per breeding den to estimate the number of adult foxes.

In a stable population, the number of breeding dens should be stable (Nakazono and Ono 1987). In our area the number of breeding dens varied between years, indicating an unstable population; this fact was confirmed by night-lighting counts (Weber et al. 1991). Changes in prey availability could explain these differences. In our area, the main prey of foxes, the water vole *Arvicola terrestris*, fluctuates considerably in numbers (Weber and Aubry preliminary information). Hewson (1986) compared different habitats, and supposed that some differences in the number of breeding dens were due to food availability. However, the cycles of the water vole are pluriannual (4–8 years) and cannot be the only reason for such substantial differences in the number of dens. Although Hewson (1986) noticed no change in the number of breeding dens according to the number of foxes killed during winter, we consider that hunting pressure has an important influence on the number of breeding dens in the following year, e.g., a strong fox hunting during the winter of 1987–1988 corresponded to an unusually low number of breeding dens in the following year (Paratte 1989). Under such unstable conditions and without having established the

social organization of the population, and its possible modification, it is very difficult to make a reliable estimation of fox number using number of breeding dens.

Regular use of breeding dens over the years has already been reported by Nakazono and Ono (1987). Some factors could influence the use of breeding dens: number of foxes, change of the mating individuals, disturbance at the moment of birth. This fact showed once again the importance of the "pool" of breeding dens in an area. Human permanent disturbances of these sites or their destruction without doubt will cause changes. A possible effect will be the decrease in fox numbers. Weber (1983) assumed that the number of dens can possibly become a limiting factor in areas with unsuitable soil. But more probably, foxes would find other sites certainly closer to houses and that would cause problems to both humans and foxes.

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Zusammenfassung

Kennzeichen und Verteilung von Aufzuchtbauen beim Rotfuchs (Vulpes vulpes) in einem gebirgigen Habitat

Fuchsbaue wurden seit 1986 in einem 30 km² großen Gebiet des Schweizer Jura gesucht und überwacht. Im Jahre 1990 wurden Lage und Verteilung der Baue untersucht, um Aufzuchtbaue mit den übrigen, anderweitig genutzten Bauen vergleichen zu können. Es wurden 62 Baue gefunden (0,33/km²). Die Aufzuchtbaue machen 19,4 % der Gesamtzahl vorhandener Baue aus (1,88/km²). Ein Vergleich der Lage von Aufzuchtbauen mit der anderer Baue zeigt nur eine Besonderheit: die Aufzuchtbaue hatten deutlich mehr Eingänge. Von Menschen geschaffene Strukturen und von Dachsen gegrabene Baue wurden als Aufzuchtbaue genutzt.

Die Aufzuchtbaue waren von Straßen und Häusern nicht weiter entfernt als die übrigen Baue, und sie waren nicht regelmäßig über das Untersuchungsgebiet verteilt. Dieselben Aufzuchtbaue wurden über mehrere Jahre benutzt. Die Benutzung und Verteilung der Aufzuchtbaue waren begrenzt von der Zahl günstig gelegener vorhandener Baue. Die Anzahl der Aufzuchtbaue kann grundsätzlich genutzt werden, um die Anzahl von Füchsen in einem Gebiet abzuschätzen. Dazu muß jedoch die soziale Organisation der betroffenen Population bekannt sein.

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